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Pasadena, California

Space-borne soil moisture measurements in support of flood hydrology: The NASA SMAP approach

Wade Crow (USDA ARS)

Dara Entekhabi (MIT)

Eni Njoku (Cal-Tech/NASA JPL)

Peggy O'Neill (NASA GSFC)

Thomas Jackson (USDA ARS)

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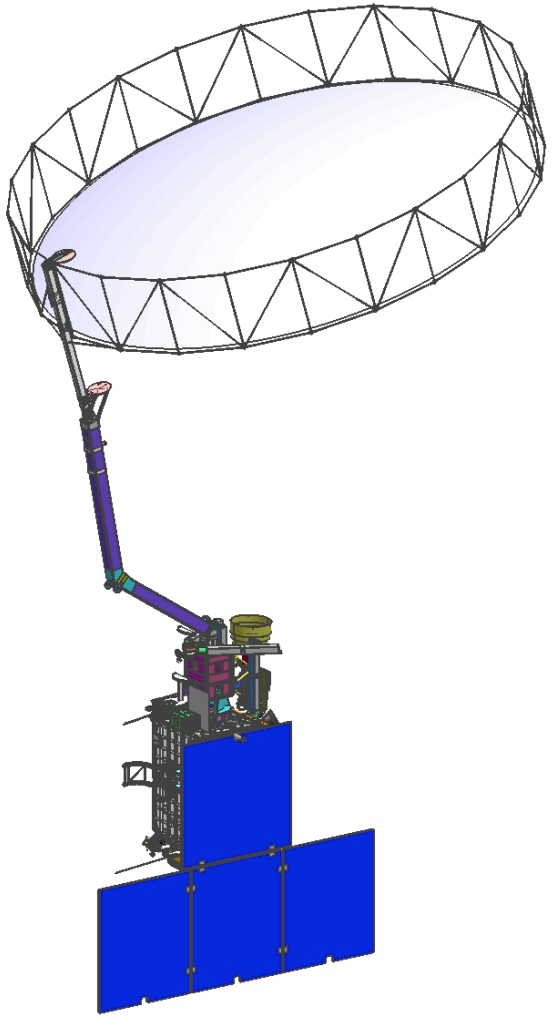
SMAP Mission Concept

SMAP Mission Concept

- SMAP is a directed NASA mission with significant heritage from Hydros
  - *Hydros risk-reduction performed during Phase A (instrument, spacecraft dynamics, science, ground system)*
- L-band unfocused SAR and radiometer system with offset-fed 6-m deployable mesh reflector rotating about nadir axis
  - *Single feed (dual-pol radar and polarimetric radiometer)*
  - *Conical scan, fixed incidence angle across swath*
  - *Contiguous 1000 km swath*
  - *Radar resolution: 1-3 km (Radar resolution degrades over center 30% of swath)*
  - *Radiometer resolution: 40 km*
- Sun-synchronous dawn/dusk orbit
- Mission Ops duration 3 years (Launch 2014)



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SMAP Science Data Products

Data Product	Description	
L1B_S0_LoRes	Low Resolution Radar σ^o in Time Order	**Global Mapping L-Band Radar and Radiometer**
L1C_S0_HiRes	High Resolution Radar σ^o, Gridded	
L1B_TB	Radiometer T_B in Time Order	
L1C_TB	Radiometer T_B, Gridded	
L3_F/T_HiRes	Freeze/Thaw Binary State (3 km)	**High-Resolution and Frequent-Revisit Science Data**
L3_SM_40km	Radiometer Soil Moisture on Earth Grid (40 km)	
L3_SM_A/P	Radar/Radiometer Soil Moisture (10 km)	
L4_C	Net Ecosystem Exchange (NEE) of Carbon (10 km)	**Observations+Model Value Added Product**
L4_SM	Surface and Root-Zone Soil Moisture (10 km)	

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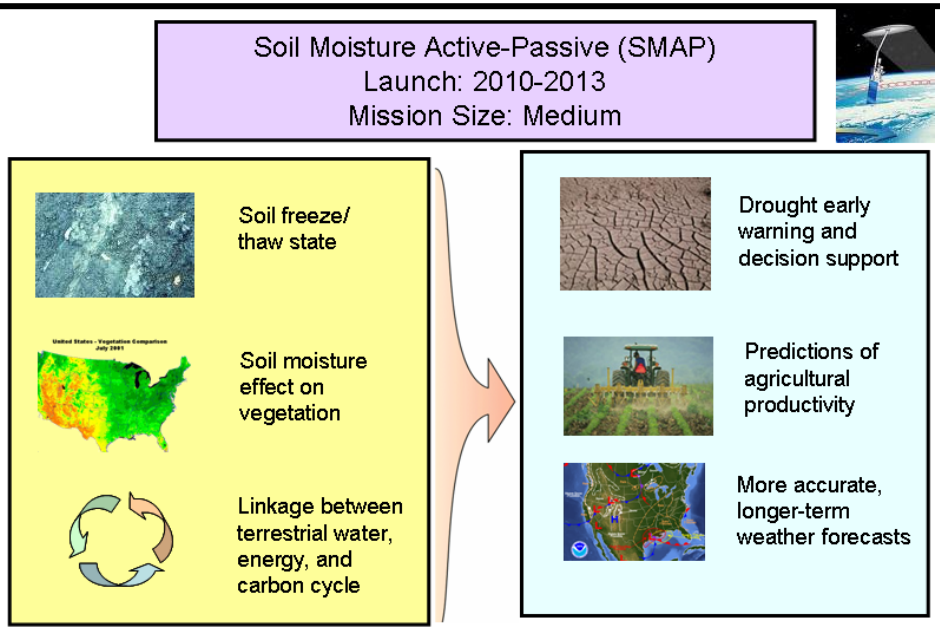
SMAP Science and Applications

SMAP in Decadal Survey

Decadal Survey Panels	Cited SMAP Applications
Water Resources and Hydrological Cycle	1. Floods and Drought Forecasts 2. Available Water Resources Assessment 3. Link Terrestrial Water, Energy and Carbon Cycles
Climate / Weather	1. Longer-Term and More Reliable Atmospheric Forecasts
Human Health and Security	1. Heat Stress and Drought 2. Vector-Borne and Water-Borne Infectious Disease
Land-Use, Ecosystems, and Biodiversity	1. Ecosystem Response (Variability and Change) 2. Agricultural and Ecosystem Productivity 3. Wild-Fires 4. Mineral Dust Production

"…the SMAP mission is ready for "fast-track" towards launch as early as 2012, when there are few scheduled Earth missions. The readiness of the SMAP mission also enables gap-filling observations to meet key NPOESS community needs (soil moisture is "Key Parameter," see 4.1.6.1.6 in IORD-II Document)." Page 4-43

SMAP is one of four missions recommended by the NRC Earth Science Decadal Survey for launch in the 2010-2013 time frame



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SMAP Science and Applications

SMAP in Decadal Survey

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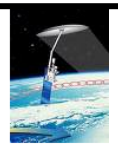
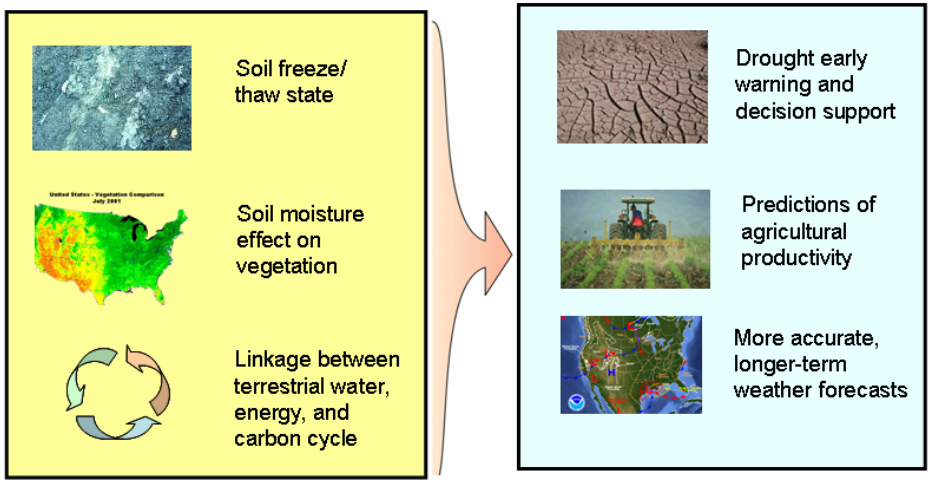
Soil Moisture Active-Passive (SMAP)
Launch: 2010-2013
Mission Size: Medium





Sources of Flood Predictability

1) Characterization of pre-storm soil moisture

2) Numerical weather prediction of extreme rainfall

3) Accurate real-time rainfall monitoring (in large basins)

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Sources of Flood Predictability

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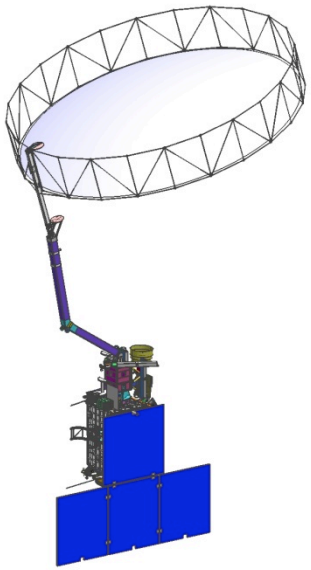

How can SMAP contribute to these sources of predictability?

Sources of Flood Predictability

1) Characterization of pre-storm soil moisture

2) Numerical weather prediction of extreme rainfall

3) Accurate real-time rainfall monitoring (in large basins)

Key issue:

Relative to existing operational approaches, how can SMAP improve our ability to characterize antecedent soil moisture conditions and associated flood risk?

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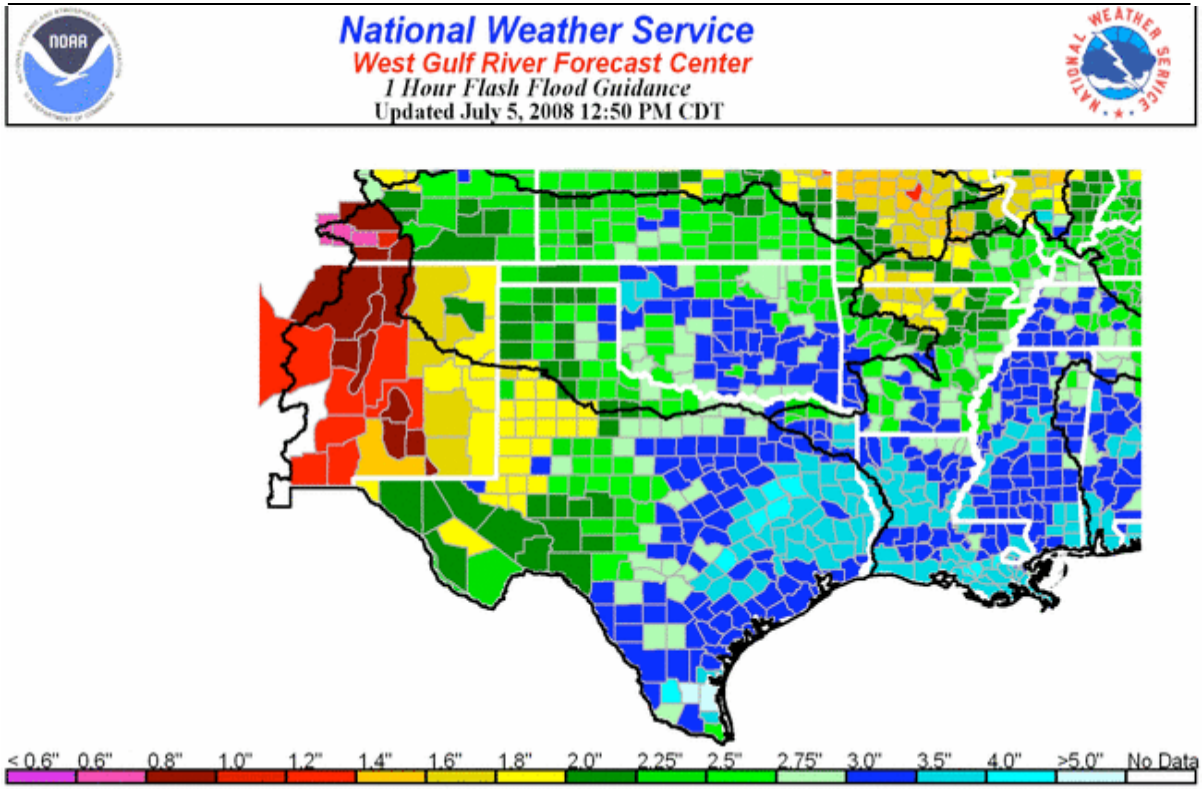
Characterization of Pre-Storm Soil Moisture

SMAP Applications



Current: Empirical soil moisture indices based on simple water model modeling.

Future: Assimilation of higher-resolution SMAP products into water balance model.

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Characterization of Pre-Storm Soil Moisture

SMAP Applications

1) **Only** RS Soil Moisture

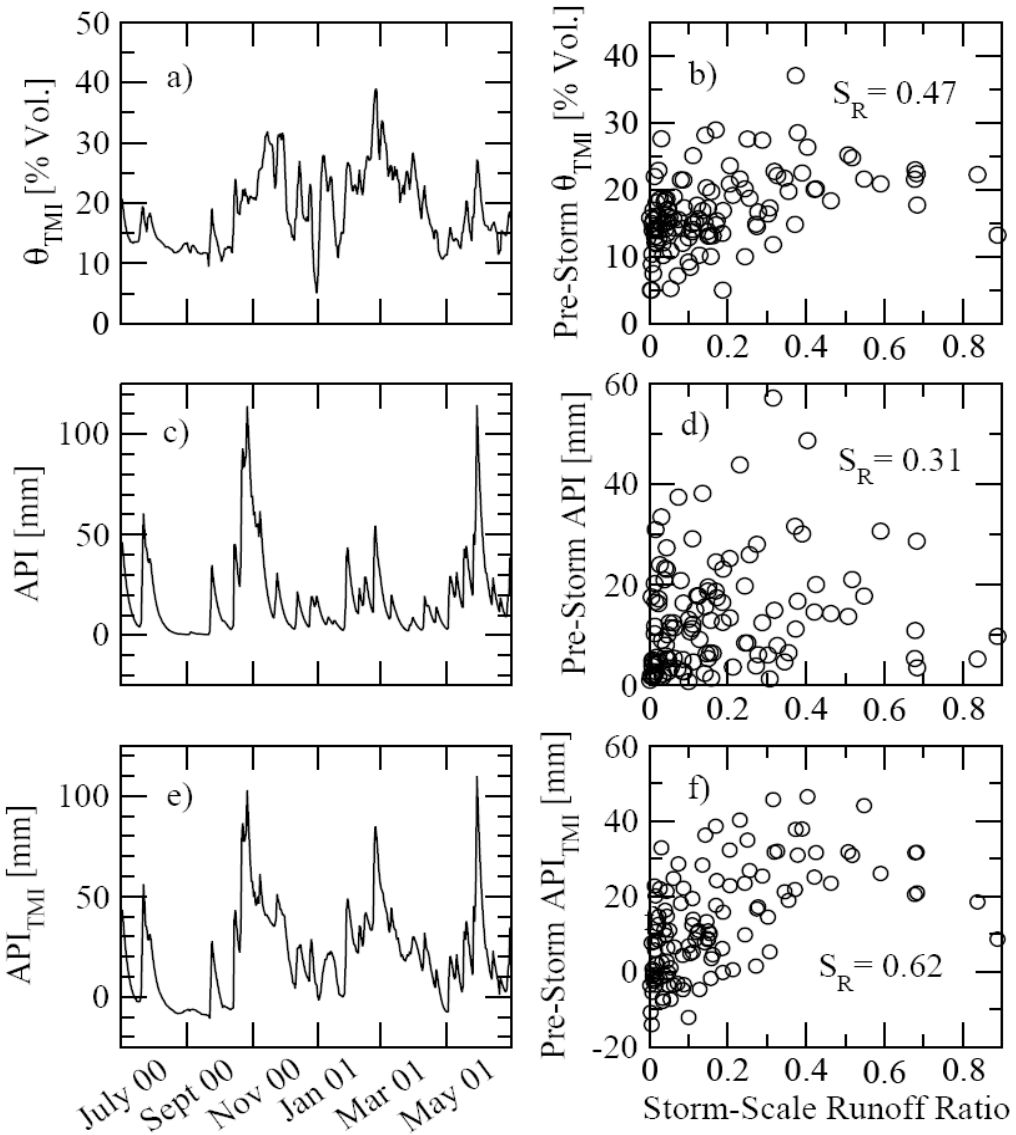
Bindlish and Jackson TMI soil moisture product

2) **Only** Water Balance Modeling

Antecedent Precipitation Index (API) model

3) Data Assimilation – Combine RS **and** Modeling

Kalman filtering



Crow et al. (2005), GRL, 32, L18401, doi:10.1029/2005GL023543.

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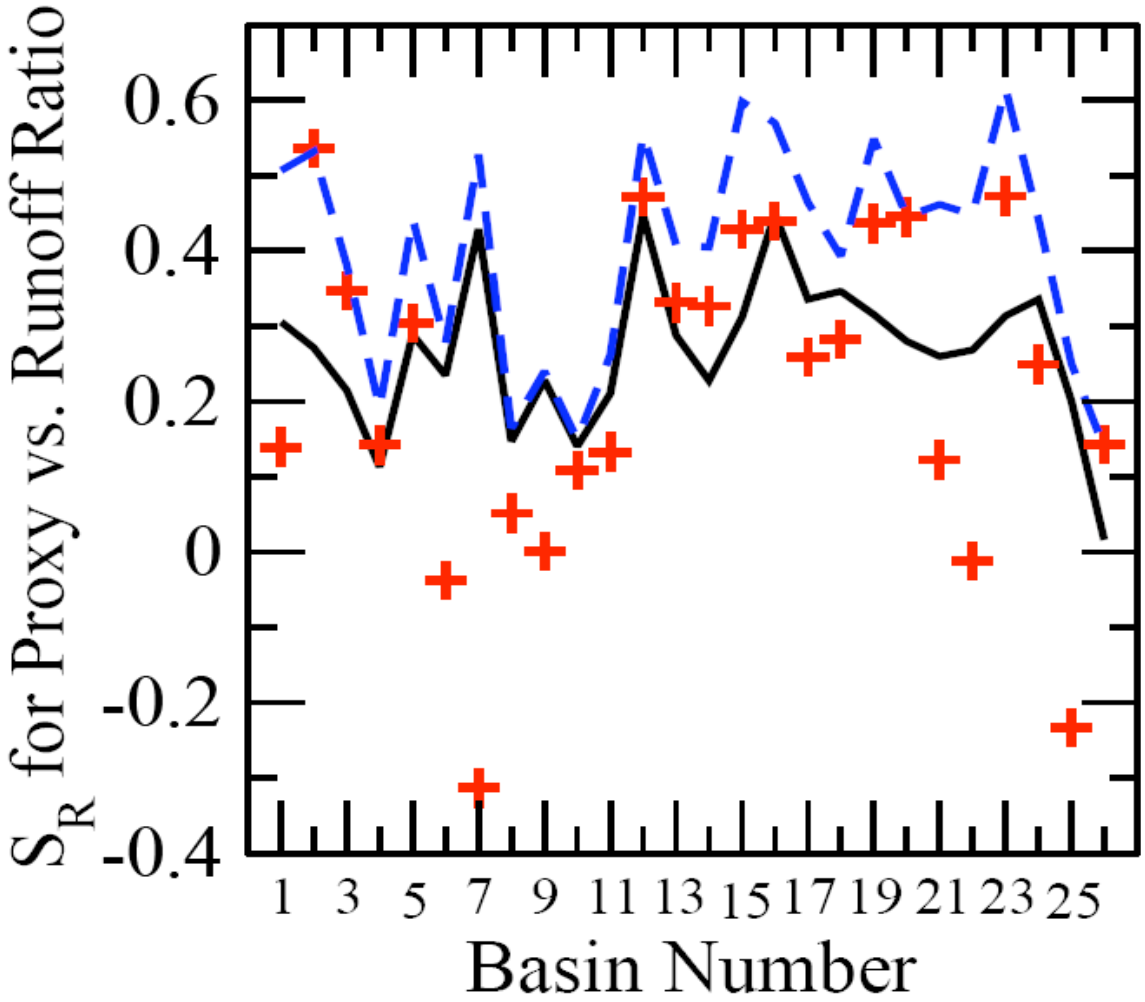
Characterization of Pre-Storm Soil Moisture

Red – Remote Sensing Only (TRMM TMI)

Black – Model Only

Blue – Remote Sensing/ Model KF Combined



(>30² km² MOPEX Basins in Southern US)

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Characterization of Pre-Storm Soil Moisture

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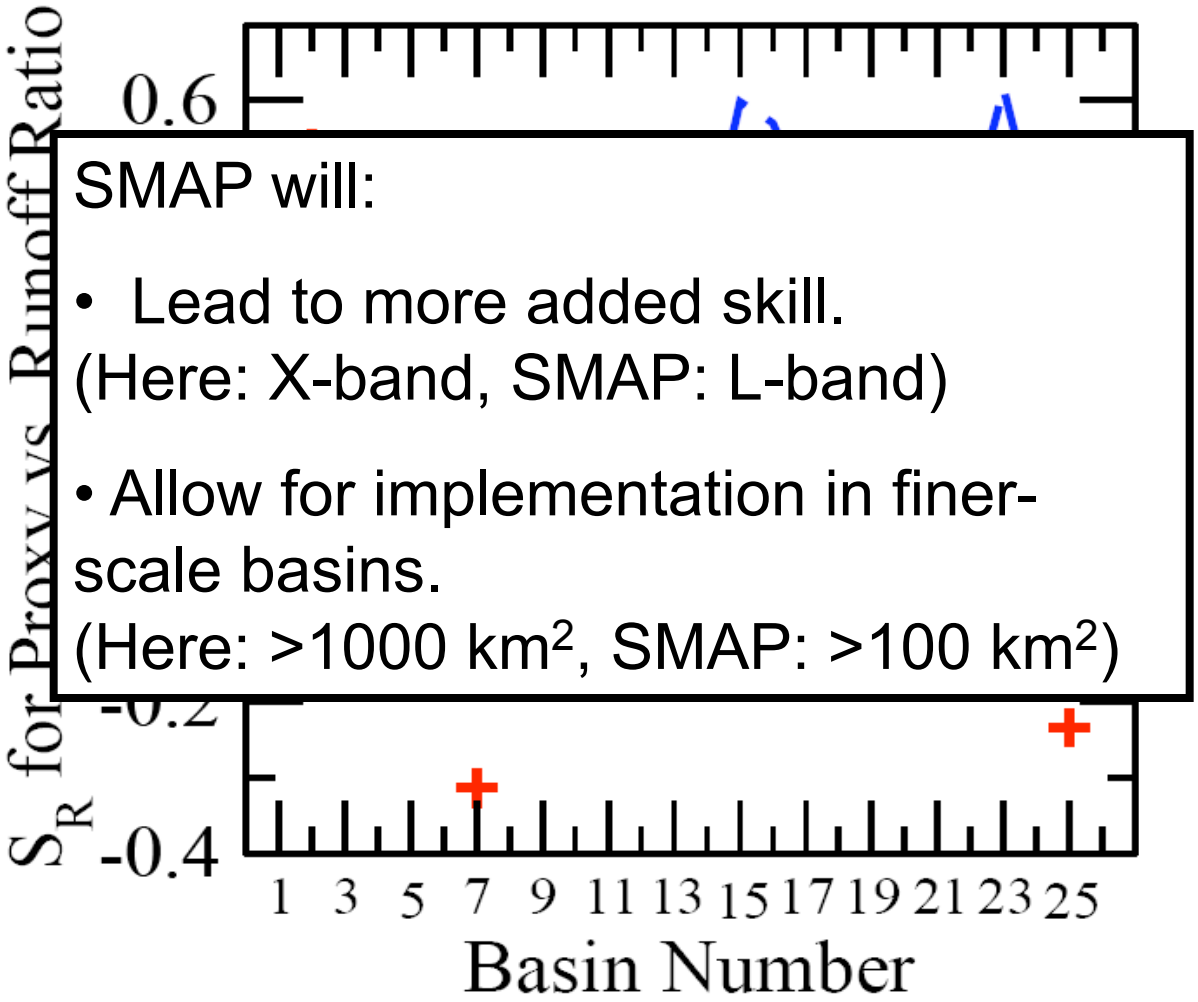

SMAP will:

- Lead to more added skill.
(Here: X-band, SMAP: L-band)
- Allow for implementation in finer-scale basins.
(Here: >1000 km^2, SMAP: >100 km^2)

(>30^2 km^2 MOPEX Basins in Southern US)

Sources of Flood Predictability

1) Characterization of pre-storm soil moisture

2) Numerical weather prediction of extreme rainfall

3) Accurate real-time rainfall monitoring (in large basins)

Key issue:

Can SMAP data products enhance the predictability of intense rainfall events associated with flash flooding?

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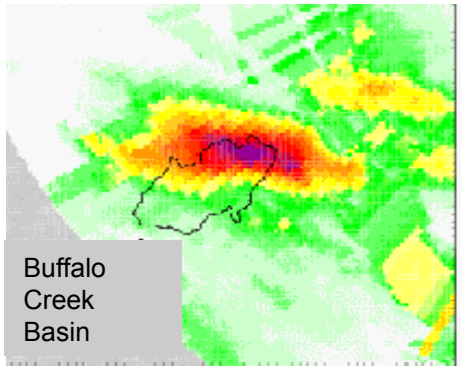
Prediction of Extreme Rainfall

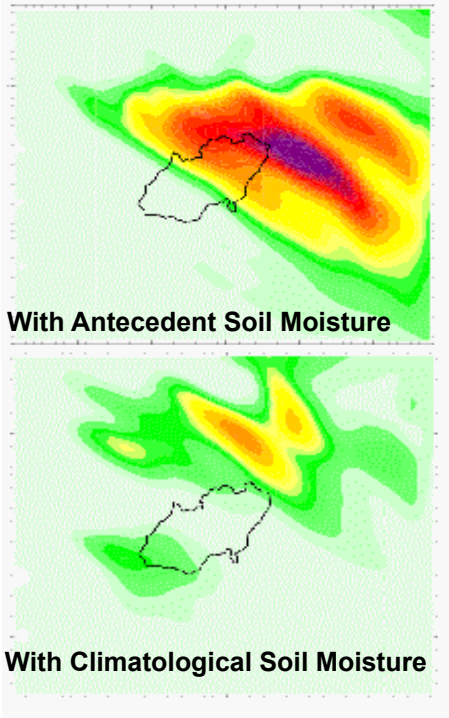
Flash flood event near Fort Collins
July 13, 1996

Chen et al. (2001), *JAS*, 58, 3204-3223.



NEXRAD Observed Rainfall
0000Z to 0400Z 13/7/96

24-Hours ahead
atmospheric model
forecasts



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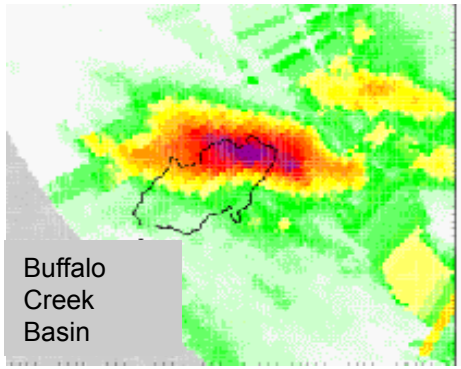
Prediction of Extreme Rainfall

Operational Weather

Flash flood event near Fort Collins
July 13, 1996

Chen et al. (2001), *JAS*, 58, 3204-3223.



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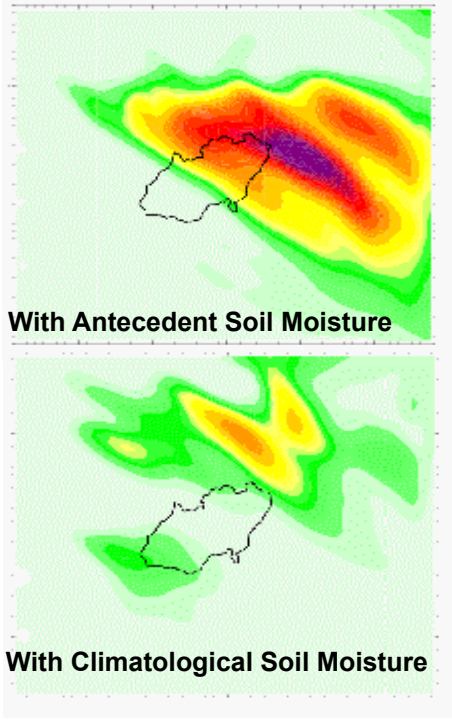

SMAP will enhance the reliability and resolution of antecedent soil moisture fields.

Sources of Flood Predictability

1) Characterization of pre-storm soil moisture

2) Numerical weather prediction of extreme rainfall

3) Accurate real-time rainfall monitoring (in large basins)

Key issue:

Can SMAP data products improve our ability to globally monitor precipitation accumulation estimates from satellite precipitation missions (now: TRMM, future: GPM)?

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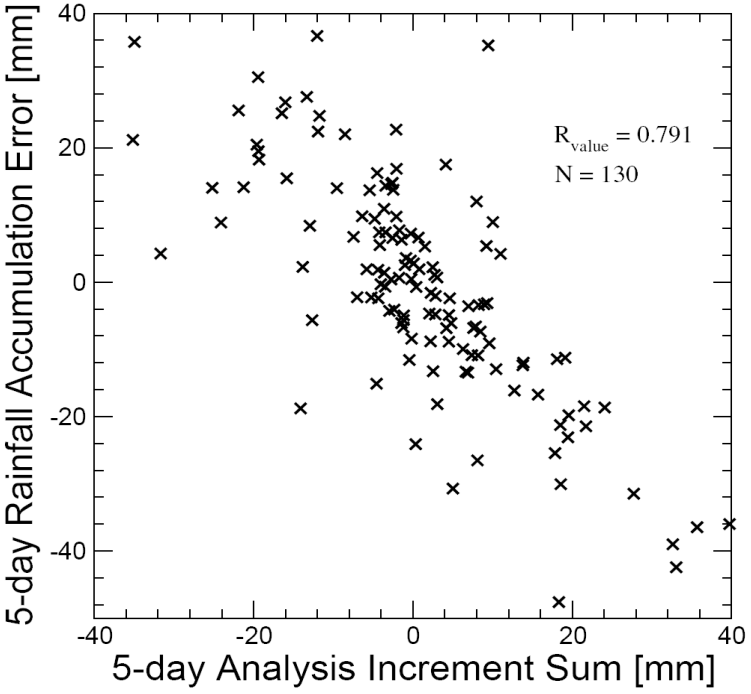
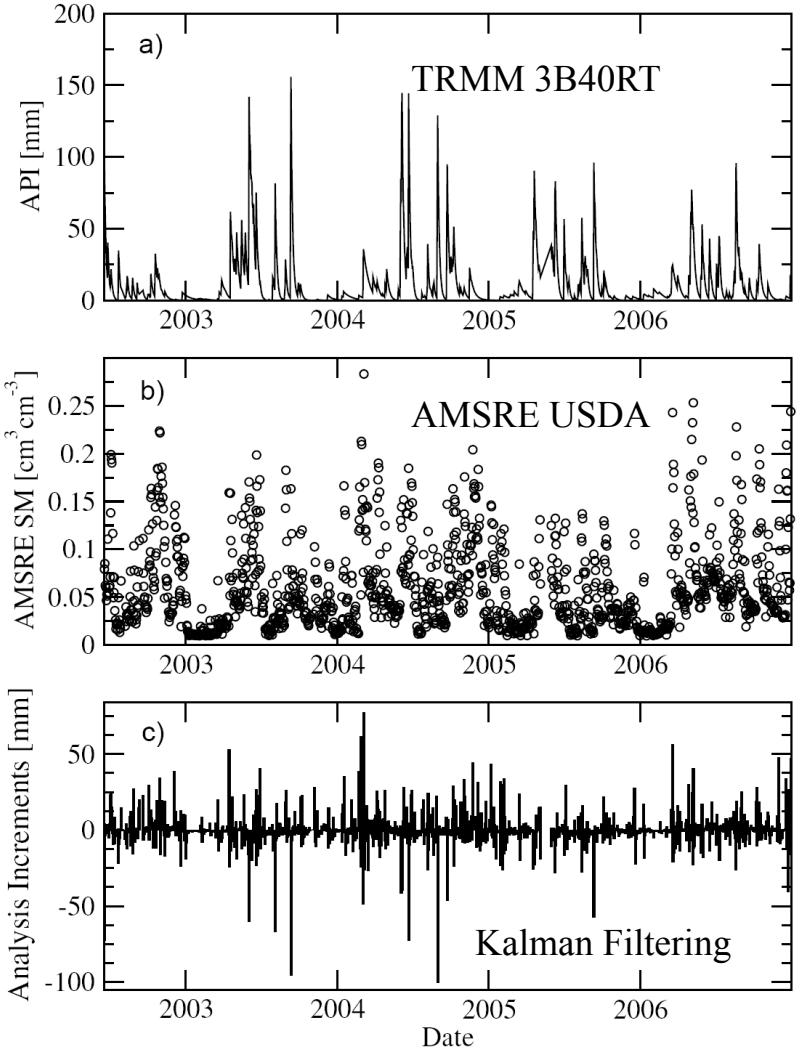
Accurate Rainfall Monitoring

SMAP Applications

Crow et al. (2009), JHM, 10(1), 199-212.





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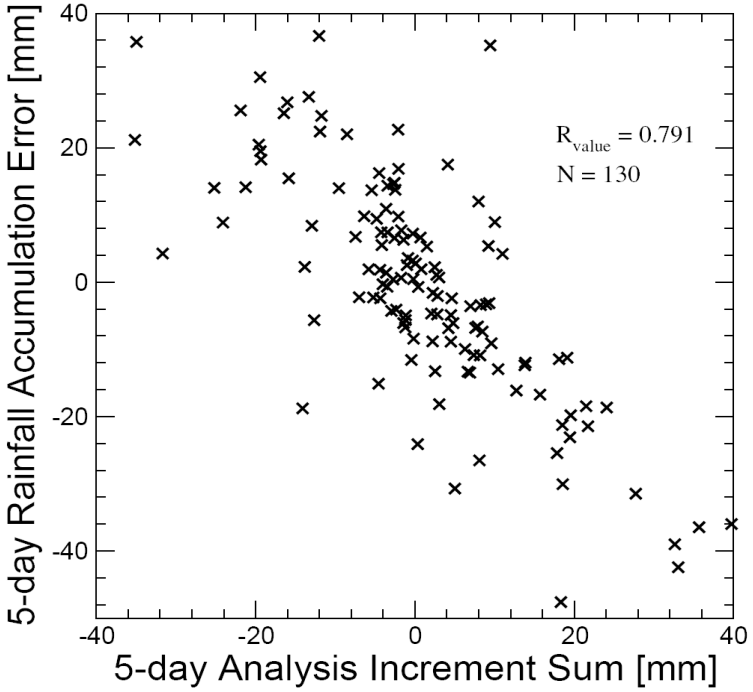
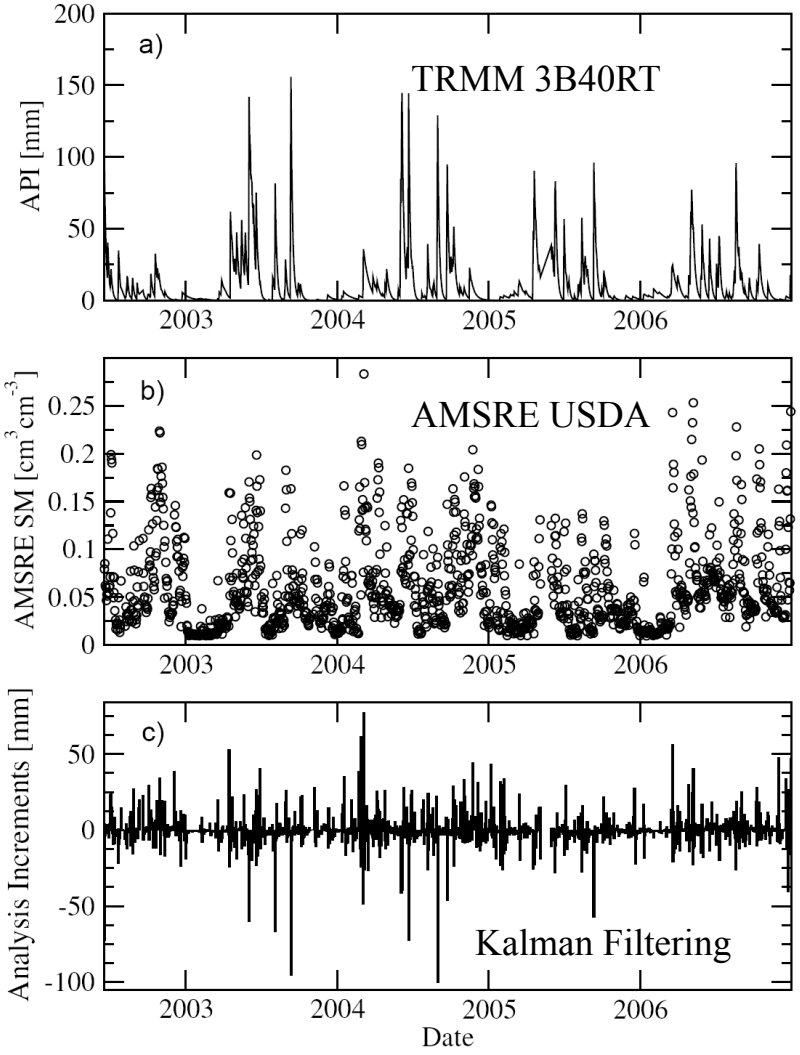


Information in RS soil moisture can be used to correct real-time TRMM rainfall accumulations



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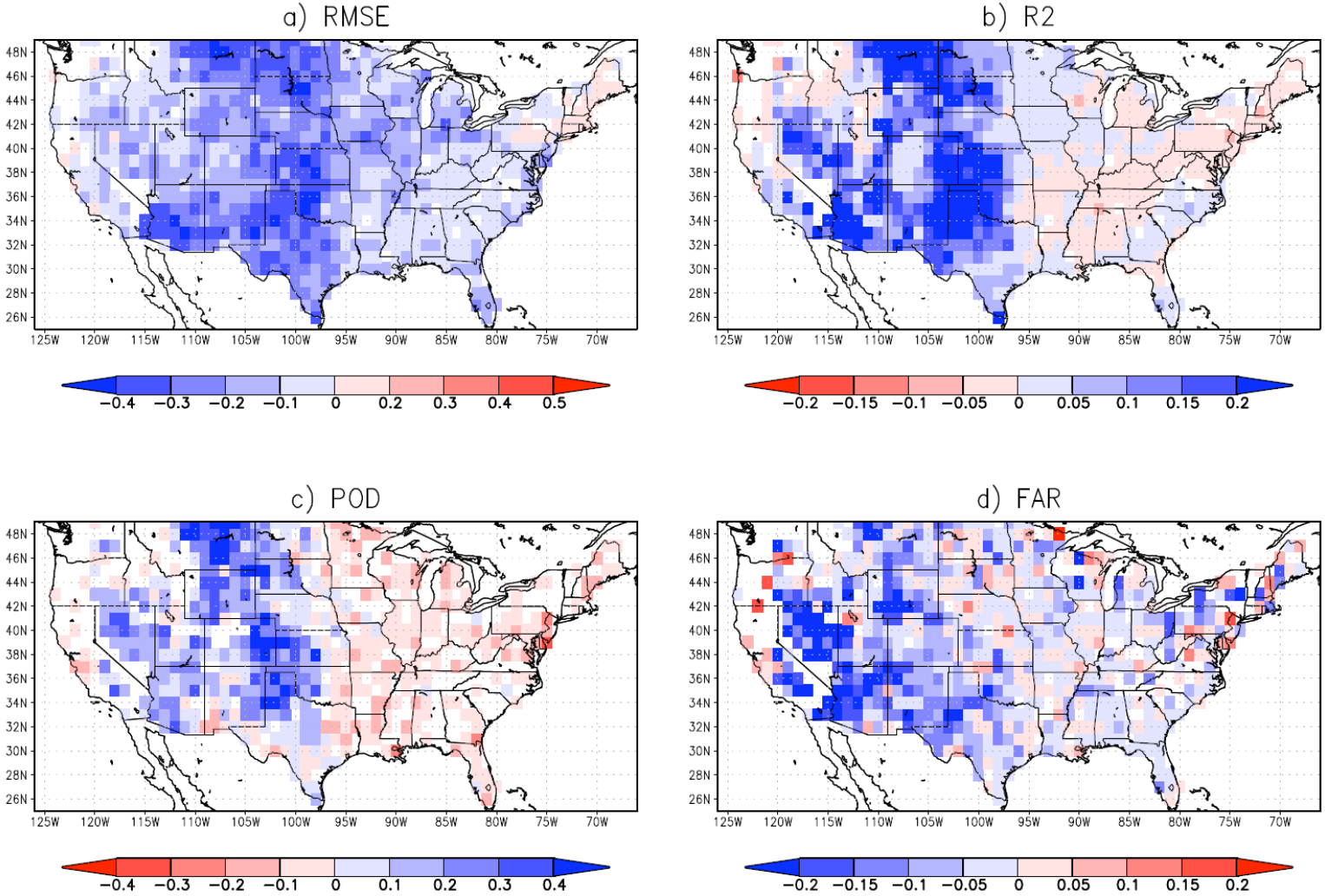
Accurate Rainfall Monitoring

SMAP Applications

Improvement in TRMM 3B40RT 3-day accumulation skill



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Accurate Rainfall Monitoring

SMAP Applications

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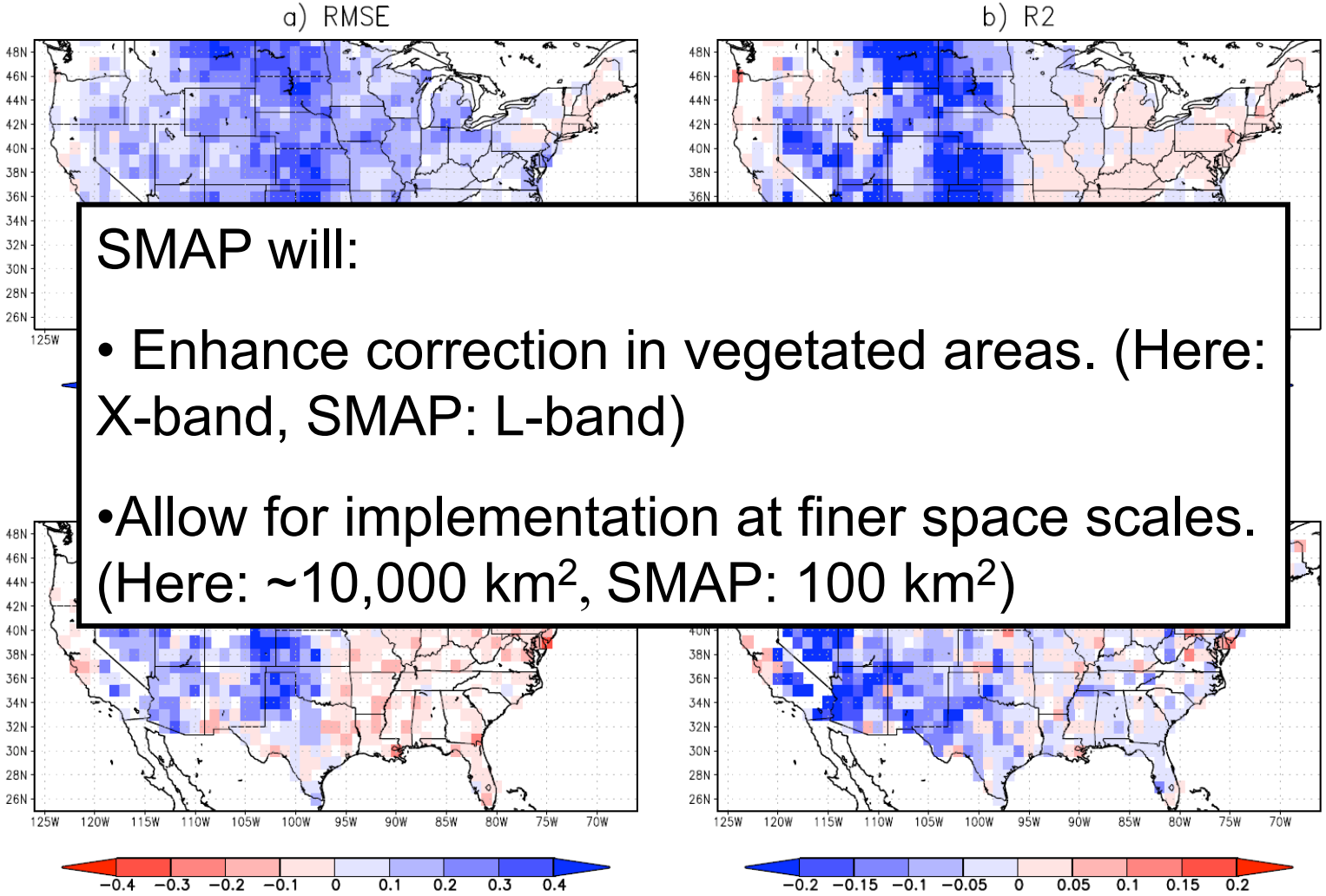

SMAP will:

- Enhance correction in vegetated areas. (Here: X-band, SMAP: L-band)
- Allow for implementation at finer space scales. (Here: ~10,000 km^2, SMAP: 100 km^2)

Crow et al. (2009), JHM, 10(1), 199-212.

Sources of Flood Predictability

1) Characterization of pre-storm soil moisture

2) Numerical weather prediction of extreme rainfall

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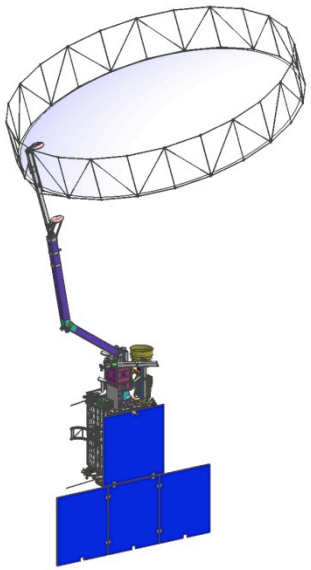

SMAP data products will enhance all three potential sources of flood predictability.

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Upcoming Relevant Event

SMAP Applications

smap.jpl.nasa.gov

SMAP Applications Workshop

September 9-10, 2009

At the NOAA SSMC-3 Building

Silver Spring, MD